SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2025
ORGANIZATION AND MANAGEMENT SERIES NO. 228

COMPARATIVE ANALYSIS OF DATA USED IN LOGISTICS – OPPORTUNITIES AND LIMITATIONS IN MANAGING WMS SYSTEMS

Monika CHŁĄD

The Management Faculty, Czestochowa University of Technology; monika.chlad@pcz.pl,
ORCID: 0000-0002-9925-6000

Purpose: The main goal of the article was to conduct a comparative analysis of two different inventory management methods, identify their advantages and disadvantages, and present recommendations for optimizing the inventory.
Design/methodology/approach: The research was conducted in the form of a case study in a manufacturing company, in which two approaches to inventory management were compared: traditional, using an Excel spreadsheet and modern - using a WMS system. The analysis was based on empirical data, observations of logistics processes and benchmarking assessment of efficiency indicators.
Findings: The study results showed a significant advantage of the WMS system over traditional methods. WMS allows for more accurate inventory management, faster order fulfillment, reducing the number of errors and complaints, as well as reducing unit costs of warehouse operations. The key conclusion is the recommendation to fully implement WMS throughout the entire warehouse.
Research limitations/implications: The analysis is based on empirical data from one operating environment in which the WMS system was already partially implemented, which could have influenced the dynamics and scale of the achieved effects. Moreover, the study does not take into account the full costs of implementing a WMS system from scratch in organizations that do not have IT infrastructure or trained staff. In future research, it is worth expanding the scope to compare different types of warehouses (e.g. high-bay, cold stores, distribution centers) and also take into account the long-term effects of implementing WMS and RFID technologies, including the impact on employee turnover, organizational culture and operational continuity.
Practical implications: The study results provide practical recommendations for logistics and manufacturing companies that are considering implementing WMS systems. It has been shown that even partial implementation of the system can lead to a quick improvement in the efficiency and quality of warehouse services.
Social implications: Improving work organization in warehouses can lead to reduced employee stress, reduced human errors and improved operational safety. Better customer service has a positive impact on business relationships and consumer satisfaction.
Originality/value: This study adds original value to the literature on the subject by directly comparing two commonly used inventory management methods in a real warehouse environment.
Keywords: WMS, warehouse management, process.
Category of the paper: Research paper.

1. Introduction

The development of information technologies enables increasingly better handling of physical processes in which logistics flows occur (Demir, Salkin, 2020; Kocaoglu, 2023). Data on these flows are increasingly and more easily acquired systemically using automatic identification techniques (Ringsquandl et al., 2014). Classic, document-based methods of feeding IT systems with data are losing importance. More and more often, data appears in the form of linear or two-dimensional barcodes, as well as transponders (radio tags) (Pontoh et al., 2024). Modern automatic identification techniques are implemented in IT systems of the WMS class or MES (Manufacturing Execution System) class, which feed ERP systems with real data captured by ADC (Automatic Data Capture) solutions (Jałowiecki et al., 2018; Witsch, Vogel-Heuser, 2022).

In warehouse management, information is one of the most important resources. Its management determines the possibility of operating on the warehouse services market (Richards, 2017). This seemingly complicated chain of information flows taking place in the area of actual operational logistics becomes simple if the data processed by these types of IT systems are treated in a consistent and unique manner. A package with goods, regardless of whether it was created in a production hall or stored in a warehouse and then sold, should be "seen" in each of these systems in the context of its identical physical characteristics: it has unchanged dimensions, constant weight, and unchanged content (Lapine, Ailyn, 2024).

The main goal of the article was to conduct a comparative analysis of two different inventory management methods, identify their advantages and disadvantages, and present recommendations for optimizing the inventory management process in a selected warehouse.

2. Literature review

There are many inventory management systems available on the market that help companies effectively monitor, control, and optimize their inventory. The most commonly used in warehouse management are ERP systems (Ali et al., 2024; Bhatt, 2024; Garg, Venkatakrishna, 2022; Jałowiecki et al., 2018; Nowakowska et al., 2018; Pontoh et al., 2024). The term ERP refers to a set of related applications that work together. An ERP system is used to manage processes carried out in a warehouse enterprise or to support cooperating groups. Companies collect data from customers and adjust production or orders according to their needs. The use of ERP systems to support warehouse processes allows for management control in the enterprise, which facilitates the optimization of intra-warehouse processes. A key element of an ERP system is a common database, which is usually used by all other applications.

ERP systems are flexible and can be adapted to different types of warehouses. Individual applications within the ERP system can operate independently of each other. The ERP system allows for planning processes at every stage of the movement of goods.

Another system commonly used by companies is the WMS system, which is used to manage the movement of products in warehouses (Jałowiecki et al., 2018; Lapine, Ailyn, 2024; Mulla, 2024; Prakoso et al., 2025; Richards, 2017; Verwijmeren, 2004). In particular, WMS supports the management of high-bay warehouses and is used to coordinate warehouse work in accordance with the ABC classification. WMS systems have a significant impact on streamlining the processes taking place in warehouses and supporting the work of logistics operators both in the warehouse and in terminals. These are commonly used systems for handling a large number of diversified shipments. The use of WMS systems brings benefits in the case of handling shipments from many senders and directed to many recipients. A large number of storage locations and the variety of shipments in the warehouse require precise location of goods, and here WMS systems play an important role. Thanks to them, it is possible to effectively control the flow of goods in the warehouse, which translates into better control of warehouse turnover. Thanks to the ability to obtain information from various sources, WMS systems enable quick location of each batch of goods and finding any shipment. Cooperation of these systems with printers allows for generation of appropriate logistic labels, which are used to mark pallet units. In addition, the WMS system has the ability to read information contained on labels generated by other entities.

The WMS system also has an additional function of optimizing the preparation of shipments from the warehouse through the efficient use of available resources. This tool allows for the picking of shipments in accordance with the order, which helps to optimize the process of preparing goods for shipment. The WMS system allows for continuous control of all activities carried out in the warehouse. It is particularly effective in the daily management of large warehouses that handle a significant number of parcels from different senders and for different recipients. The WMS system acts as a supplement to the ERP system, providing the possibility of mutual sharing of data between these two systems. It is also possible to equip the ERP system with a WMS module, which supports logistics services. The main task of the WMS system is the error-free location of goods in the warehouse and control of warehouse management. WMS provides real-time information on stock levels, in accordance with specific criteria established for a given warehouse. Stock levels are recorded in the WMS system together with information on the place where the goods are stored, which allows for effective quantitative and assortment control of the stored products.

The CRM (Customer Relationship Management) system is a set of tools and procedures supporting customer relationship management (Jenab, Khoury, 2022). CRM allows you to maintain constant contact with customers and, above all, allows you to measure their satisfaction throughout the product life cycle. Implementing a CRM system is particularly important for companies providing services, because the customer assesses the quality of services only after the order has been completed. The CRM system is also compatible with other systems used in warehouse management.

MRP (Material Requirements Planning) systems are material requirements planning systems that integrate information about orders, sales forecasts, and inventory levels to calculate optimal orders and production schedules (Garg, Venkatakrishna, 2022). MRP is responsible for optimizing inventory levels, the production process, determining production costs, and better utilization of infrastructure. It helps map the production process, indicates production capabilities, and suggests how to adjust production to employees or demand. The MRP system is also compatible with other systems that are used in other companies, but together fulfill orders for the same customer. The system can be used as a tool for reducing inventory levels. The MRP system supports ongoing analysis of inventory levels using the bill of materials (BOM). BOM is a list of raw materials, subassemblies, assemblies, and parts necessary for the production of the final product. The BOM should be complete and contain specified names or indexes of materials and their quantities needed for production.

The SCM (Supply Chain Management) system is an IT solution that facilitates the functioning of an enterprise (Demir, Salkin, 2020; Hosseinzadeh Lotfi et al., 2023; Shafiee et al., 2021; Simchi-Levi et al., 2004; Stadtler, 2005). It covers the management of the entire supply chain, including inventory management. It enables tracking and coordination of processes from suppliers to customers, minimizing the risk of shortages and ensuring improved operational efficiency. Thanks to the synchronization of material flow, it is possible to continuously control inventory levels in the context of changing demand. Sudden drops or increases in sales are immediately corrected by suppliers, who receive quick information on the need to adjust production. In addition to the flow of information, the SCM system also deals with the flow of products and services. Internal SCM is used for ongoing management of the enterprise. People responsible for individual production cycles receive current information on demand, e.g. for components or analysis of the distribution department. In turn, the external distribution system uses data received from the internal system and, on the basis of this, informs suppliers about product needs or customers about the progress of the order. The SCM system also plays a role in the product design phase. Cooperation with customers allows the product to be adapted to their needs. Design using the SCM system takes into account the sources of supply, the market situation, and research is carried out on the market and distribution of products.

Thanks to the above systems, logistics can benefit from the latest technologies, such as electronic data interchange (EDI) (Simchi-Levi et al., 2004), barcodes and electronic markets. EDI is a system that was introduced in the 1980s for the exchange of information between two entities. It was initially used by the United States Department of Defense. The development of electronic data interchange has made it widely used in both the public and private sectors. EDI is a tool for the exchange of information that uses modular software based on integrated information systems standards.

In the TSL (transport – forwarding – logistics) industry, systems supporting the implementation of transport are very important (Kocaoglu, 2023; Raptis et al., 2019). Companies are increasingly deciding to use the transport services of logistics operators, who take over some of the responsibilities related to customer service. This, in turn, ensures the correct and fast flow of information between the customer and the manufacturer. The growing popularity of online platforms allows manufacturers to increasingly use direct contact with logistics operators and customers. Thanks to online platforms, manufacturers and customers have ongoing control over the process from both the manufacturer's and the customer's perspective. After the manufacturer transfers the shipment to the customer, the logistics operator updates the status of the order and informs both parties about the current stage of product processing. This information is available to the manufacturer and the customer after logging in to the platform or can be sent via SMS or e-mail. After receiving the order, the customer confirms receipt of the goods, and the system immediately informs all parties that the shipment delivery process has been completed. The possibilities of using the IT system are determined by many interrelated factors. The decisive factors include: software, human resources, organizational elements and information elements.

Modern warehouse management methods are constantly evolving, enabling the introduction of technological innovations in the form of advanced information systems. The introduction of such systems is aimed at improving the flow of information and goods in the warehouse. They enable more efficient and precise inventory management, which translates into increased efficiency and reduced operating costs. Warehouse systems based on modern technologies enable fast and accurate tracking of the flow of goods, which significantly facilitates warehouse management and inventory control. They also enable shorter order fulfillment times and reduced risk of errors. As a result, companies using modern warehouse systems have the opportunity to increase their competitiveness on the market and improve customer relationships through faster and more precise order fulfillment.

3. Research Methodology

The analysis conducted focused on assessing the effectiveness of inventory management in the warehouse belonging to the surveyed company. The study was based on a comparison of two tools used: a traditional Excel spreadsheet and a WMS (Warehouse Management System) class IT system. The analysis was comprehensive and included both a review of the functionality of both solutions and their practical application in the context of real logistics processes carried out in the warehouse. Comparing the Excel spreadsheet and the WMS system not only allowed us to indicate their strengths and weaknesses, but also provided valuable information for making strategic decisions regarding the development of the warehouse's

IT infrastructure. The results of the analysis showed that modern warehouse management systems, such as WMS, offer significantly greater possibilities in terms of efficiency, data accuracy and process automation, which has a direct impact on the quality of customer service and the optimization of logistics costs. Benchmarking is a method of comparative analysis consisting in assessing the effectiveness of processes, tools or systems by comparing them with other solutions - often considered more effective or modern. In the context of this study, benchmarking was used to compare two approaches to inventory management: a traditional, Excel-based approach and an automated, WMS-based approach. The aim of the benchmarking was to identify differences in performance, accuracy, and functionality of both solutions and to identify best practices that can be implemented in the warehouse to improve operational efficiency.

4. Results and Discussions

In order to obtain a more complete picture of the effectiveness of inventory management methods in the analyzed warehouse, a comparative benchmarking analysis of the most important performance indicators was conducted. The main objective of the study was to compare two different approaches to inventory management - a classic solution based on Microsoft Excel spreadsheets and a modern, integrated WMS (Warehouse Management System). The scope of the work carried out included: assessment of key performance indicators (KPI) for both systems,

- identification of basic differences and their impact on the efficiency of warehouse processes,
- formulation of conclusions and recommendations for the examined enterprise.

The presented analysis allowed for a comprehensive assessment of the effectiveness of the warehouse processes and indicated specific areas that could be optimized. The first of the indicators considered was the accuracy of inventory levels (Figure 1 and Figure 2). This parameter reflects the extent to which the data recorded in the system reflects the actual warehouse status. The WMS system ensures full accuracy of inventory levels, which means that the accounting data is 100% consistent with reality. In the case of Excel, although the result of 90% is relatively high, it can lead to errors in picking and ineffective inventory management. The analysis of the level of customer service - measured by timeliness and compliance with order fulfillment - showed the advantage of WMS. This system achieved a result of 99.6%, while Excel achieved 95.6%. Higher turnover in the case of WMS means that inventory is replaced faster, which indicates more efficient goods management. The system better matches stock levels to current demand, reducing the risk of goods being out of date or in arrears. Real-time data availability is one of the greatest advantages of WMS systems. Excel does not provide current information, which makes it difficult to make quick operational decisions. WMS provides full visibility of the warehouse status at any time. Although the actual operating costs of WMS are higher, their value has been "reversed" on the graph to better illustrate the efficiency of the system. WMS generates lower unit costs of operations in the long term, thanks to automation and reduced errors.

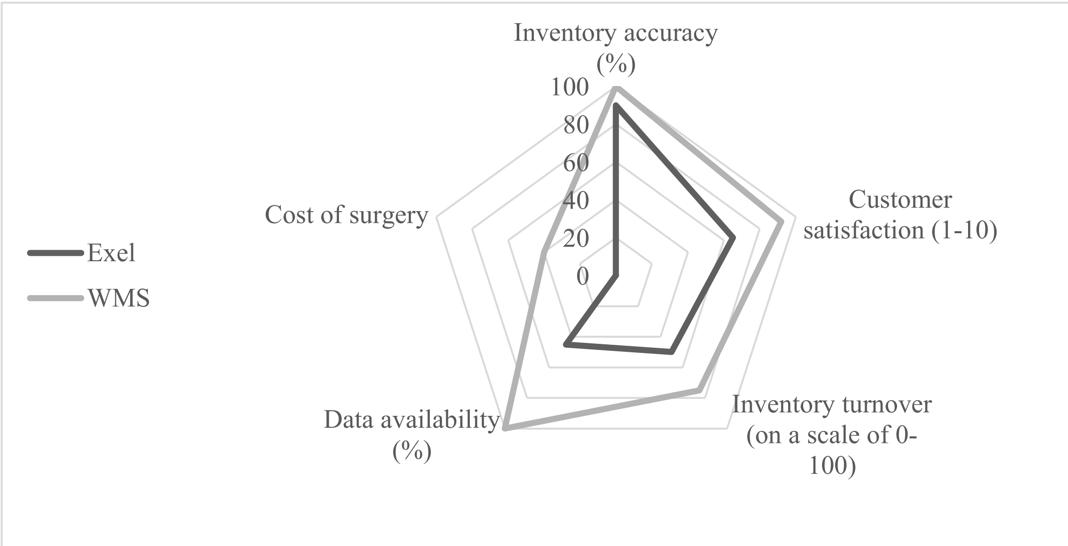

Figure 1. Comparison of quality metrics in radar approach – Excel vs WMS.

Source: Own study based on data from the surveyed enterprise.

The data clearly shows that WMS outperforms Excel in every key area: accuracy, customer service, inventory rotation, data availability, and cost optimization. The only challenge is the initial investment, which can be compensated by significantly better performance indicators in the long run.

In the context of warehouse space management, WMS enables dynamic location planning, optimization of goods layout and effective use of the full warehouse capacity.

Figure 2. Comparison of key performance indicators – Excel vs WMS.

Source: Own study based on data from the surveyed enterprise.

Although WMS is associated with higher implementation costs, this system contributes to reducing errors, limiting complaints and reducing unit costs, as shown in Figure 3.

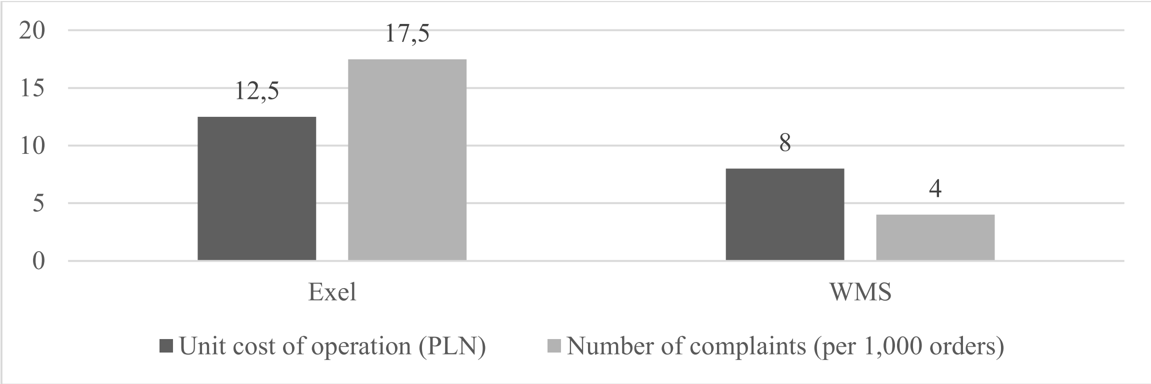

Figure 3. Unit cost of the operation and number of complaints.

Source: Own study based on data from the surveyed enterprise.

The WMS system, despite higher initial costs (e.g. implementation, licenses), generates **lower unit costs** of warehouse operations in the long term. This is due to process automation, less manual work and fewer errors. Excel, although cheap to implement, requires more human work, which translates into higher operating costs. The number of complaints in the case of Excel is more than four times higher than in the case of WMS. This means that inventory management in Excel carries a much higher risk of picking errors, delays, delivery discrepancies or incorrect documentation. Thanks to precise data and automated controls, WMS significantly reduces the number of errors and increases the reliability of the warehouse process. WMS not only reduces unit costs of operations, but also reduces complaints, which in practice means saving time, money and building better relationships with customers. Excel, on the other hand, although it may seem economical at first glance, generates high hidden costs resulting from inefficiency and errors.

The next interpreted data is the order processing time in minutes and the unit cost of the operation (Figure 4).

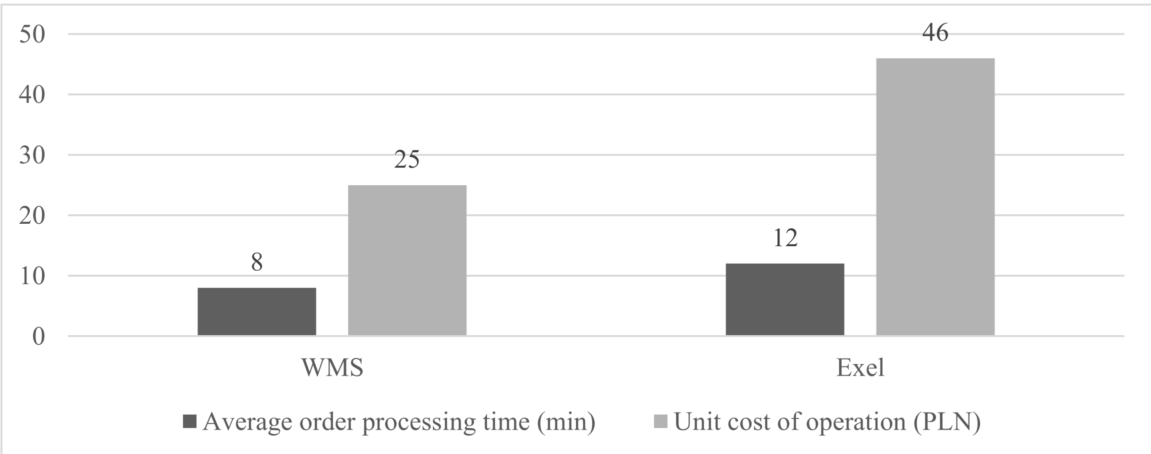

Figure 4. Summary of order processing time and operating costs.

The WMS system allows for a significant reduction in order fulfillment time – by almost 45%. This is due to the automation of warehouse processes, better work organization and elimination of unnecessary operations (e.g. manual search for information or physical checking of the location of goods). Excel, which is based on manual actions, generates delays and extends service. The lower unit cost of the operation in the case of WMS is a direct effect of automation, reduction of errors and time savings. Excel, although it does not require specialist tools, involves more human work and is more prone to errors, which generates higher hidden costs. The WMS system speeds up the service process and reduces its costs, which is especially important in environments with a large number of warehouse operations. Excel, although simple and easily accessible, becomes inefficient in a situation where time and reliability count.

Additional analysis showed a correlation between the number of picking errors and the number of complaints. As part of the analysis of the quality of warehouse operations management, two methods were compared in terms of the number of picking errors and the number of complaints that may result from these errors (Figure 5). WMS ensures a significantly lower failure rate of the picking process.

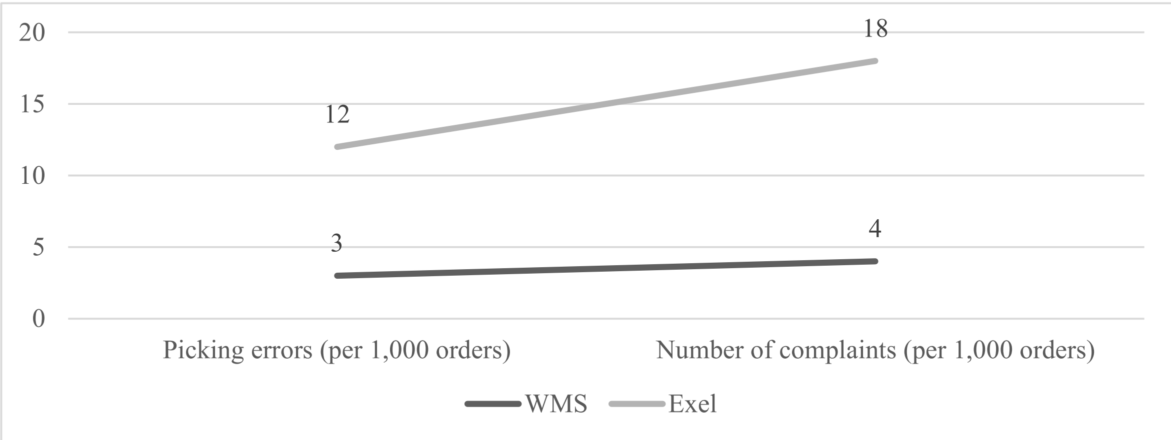

Figure 5. Relationship between picking errors and complaints.

Source: Own study based on data from the surveyed enterprise.

The presented data clearly show a correlation between the number of picking errors and the number of complaints. In the case of the Excel system, where the number of errors reaches 12 per 1000 orders, the number of complaints is as much as 18. For comparison, when using the WMS system, the number of errors drops to 3 and complaints to 4. This proves that process automation and greater data precision significantly reduce the risk of customer dissatisfaction and operational burdens.

Implementing a WMS system significantly improves the quality of inventory management compared to working with Excel sheets. Automation, precise data, optimal space management and fewer errors translate into increased operational efficiency. The only limiting factor may be the cost of implementation, which is however balanced by long-term benefits.

5. Summary

The main objective of the article was to conduct a comparative analysis of two different methods of inventory management in the studied warehouse - using the WMS system and Excel spreadsheets. The aim was to identify their advantages and disadvantages and to present recommendations for optimizing the inventory management process in the warehouse. During the analysis, detailed studies of the existing inventory management processes in the selected warehouse were conducted, where both methods were used in parallel.

Summarizing the conducted analyses, it was clearly indicated that the studied warehouse should extend the use of the WMS system to all the clients served, who were previously managed using Excel spreadsheets. Managing a large number of warehouse operations in Excel turned out to be ineffective and problematic, especially in the context of data accuracy, time-consuming operations and susceptibility to human error. Implementing the WMS system for the remaining clients will significantly increase the efficiency of inventory management, streamline order execution and reduce the risk of errors and complaints.

A significant argument in favor of expanding the existing WMS system, instead of implementing it from scratch, are the measurable economic and organizational benefits. The warehouse already has the technical infrastructure necessary to operate the system – including servers, network and appropriate software – which eliminates the need to incur investment costs in this area. What is more, the warehouse staff has already been trained in the use of the WMS, so the integration of new customers with the system does not require intensive training, which additionally shortens the implementation time and reduces its costs.

From a licensing perspective, adding additional clients may not generate additional costs if the warehouse has a licensing model that covers multiple users or clients. Even if additional licenses need to be purchased, their cost will be significantly lower than in the case of a full, new system installation. It is worth emphasizing that WMS systems are designed for easy scalability and servicing many clients simultaneously. Therefore, expanding the scope of use does not require rebuilding the system architecture, which reduces the need for adjustments and additional investments.

The joint use of a single WMS system by many customers in the same warehouse also brings operational benefits. It enables better coordination of orders, standardization of procedures and more efficient flow of information, which directly translates into higher efficiency of logistics and inventory management. Therefore, the implementation of a WMS system for all warehouse customers is not only justified from the point of view of operational efficiency, but also allows for cost optimization and increased competitiveness of warehouse services. However, WMS it is not a universal system. Its implementation requires appropriate IT infrastructure, trained staff and high initial costs. It may not be profitable for small companies or simple warehouses. The effectiveness of WMS depends on the specifics of a given warehouse and organizational conditions.

In addition to broadening the research scope to include different types of warehouses, there is also a need to introduce a conceptual framework that can systematically organize the findings and serve as a theoretical anchor for future studies. The current research lacks a unified model for evaluating inventory systems, which limits comparability and generalizability across different operational contexts. To address this gap, a five-dimensional conceptual framework is proposed, covering:

- Technological dimension – system integration, real-time data availability, automation, and scalability.
- Operational dimension – inventory accuracy, order fulfillment time, error rates, and complaint volume.
- Organizational dimension – staff competencies, user acceptance, and structural change readiness.
- Economic dimension – implementation costs, unit operating costs, and return on investment (ROI).
- Strategic dimension – alignment with business strategy, competitiveness, and innovation potential.

This framework provides a structured basis for evaluating different inventory systems (e.g., WMS, ERP, Excel-based tools) across industries and warehouse types. It can also guide the development of research instruments (e.g., questionnaires, KPIs) and support comparative or longitudinal studies on warehouse digitalization.

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